5.124

5.124 If a $\frac{3}{4}$-hp motor is required by a ventilating fan to produce a 24-in. stream of air having a velocity of 40 ft/s as shown in Fig. P5.124, estimate (a) the efficiency of the fan and (b) the thrust of the supporting member on the conduit enclosing the fan.

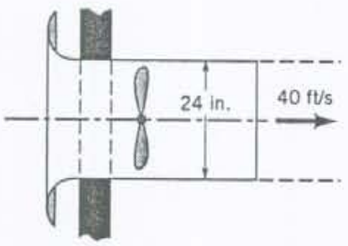

FIGURE P5.124

(a) The solution to this part of the problem is like Example 5.24. We use

$$\eta = \frac{W_{shaft} - loss}{W_{shaft}}$$

to calculate the fan efficiency.

We use the energy equation (Eq. 5.82) for flow through the control volume sketched above to calculate the loss as follows

$$\frac{P_2}{\rho} + \frac{V_2^2}{2} + gz_2 = \frac{P_1}{\rho} + \frac{V_1^2}{2} + gz_1 + \underset{net\ in}{W_{shaft}} - loss$$

But $P_2 = P_1$ and $z_2 = z_1$; $V_1 \simeq 0$; $\underset{net\ in}{W_{shaft}} = \frac{hp}{\dot{m}}$

Also $\dot{m} = \rho A_2 V_2 = \frac{P}{RT}\frac{\pi d_2^2}{4} V_2$

So

$$loss = \underset{net\ in}{W_{shaft}} - \frac{V_2^2}{2} = \frac{hp}{\frac{P}{RT}\left(\frac{\pi d_2^2}{4}\right)V_2} - \frac{V_2^2}{2}$$

$$loss = \frac{\left(\frac{3}{4}\,hp\right)\left(550\ \frac{ft\cdot lb}{s\cdot hp}\right)}{\left\{\frac{\left(14.7\ \frac{lb}{in^2}\right)\left(144\ \frac{in^2}{ft^2}\right)\pi\left[\frac{24\ in.}{\left(12\ \frac{in.}{ft}\right)}\right]^2\left(40\ \frac{ft}{s}\right)}{\left(53.3\ \frac{ft\cdot lb}{lbm\cdot {}^\circ R}\right)(530\,{}^\circ R)\ 4}\right\}} - \frac{\left(40\ \frac{ft}{s}\right)^2}{2\left(32.2\ \frac{lbm\cdot ft}{lb\cdot s^2}\right)}$$

(con't)